TECOLOTE RESEARCH, INC.
Bridging Engineering and Economics
Since 1973

A Simple Approach to Assessing and Quantifying Technical, Schedule, and Configuration Risk in Cost Estimates

ISPA/SCEA Joint Conference June 2005

Kurt Brunner
kbrunner@tecolote.com
(310) 536-0011 x195

■ Los Angeles ■ Washington, D.C. ■ Boston ■ Chantilly ■ Huntsville ■ Dayton ■ Santa Barbara
■ Albuquerque ■ Colorado Springs ■ Columbus ■ Ft. Meade ■ Ft. Monmouth ■ Montgomery ■ Ogden
■ Patuxent River ■ Pensacola ■ San Diego
■ Charleston ■ Cleveland ■ Denver ■ New Orleans ■ Oklahoma City ■ Silver Spring ■ Warner Robins AFB ■ Vandenberg AFB

Contents

- ***Objective***
- ***Background***
- ***Types of Risk***
- ***TSC Risk Assessment***
- ***TSC Risk Quantification Assumptions***
- ***Establishing TSC Risk Ranges***
- ***TSC Risk Range Results***
- ***TSC Risk Application***
- ***Collaborating Data***
- ***Summary***
- ***Backup***

Objective

- ***Provide a means and rationale for estimating Technical, Schedule and Configuration (TSC) risk using a common-sense approach that generates results that correlate well with more mathematically rigorous methods.***
- ***This is not a statistically pure approach***
  - ***It's more based on a "gut feeling" understanding***

Background

- ***One of the major considerations in cost estimating is how to assess and quantify Technical, Schedule and Configuration (TSC) Risk.***
- ***There are many complex methods and formulas that do so.***
- ***These risks are ultimately subjective and judgmental in nature, no matter how they are developed and applied.***

Types of Risk
- Cost Risk

- ***Focus on "TSC" risk as opposed to "Cost" risk***
- ***Cost Risk:***
  - ***Derived by statistics and by analyzing historical data.***
  - ***Usually presented using 10/90 or 20/80 distributions***
    - ***Thereby excludes "outliers" to some extent***
    - ***"Tailors" the CER***

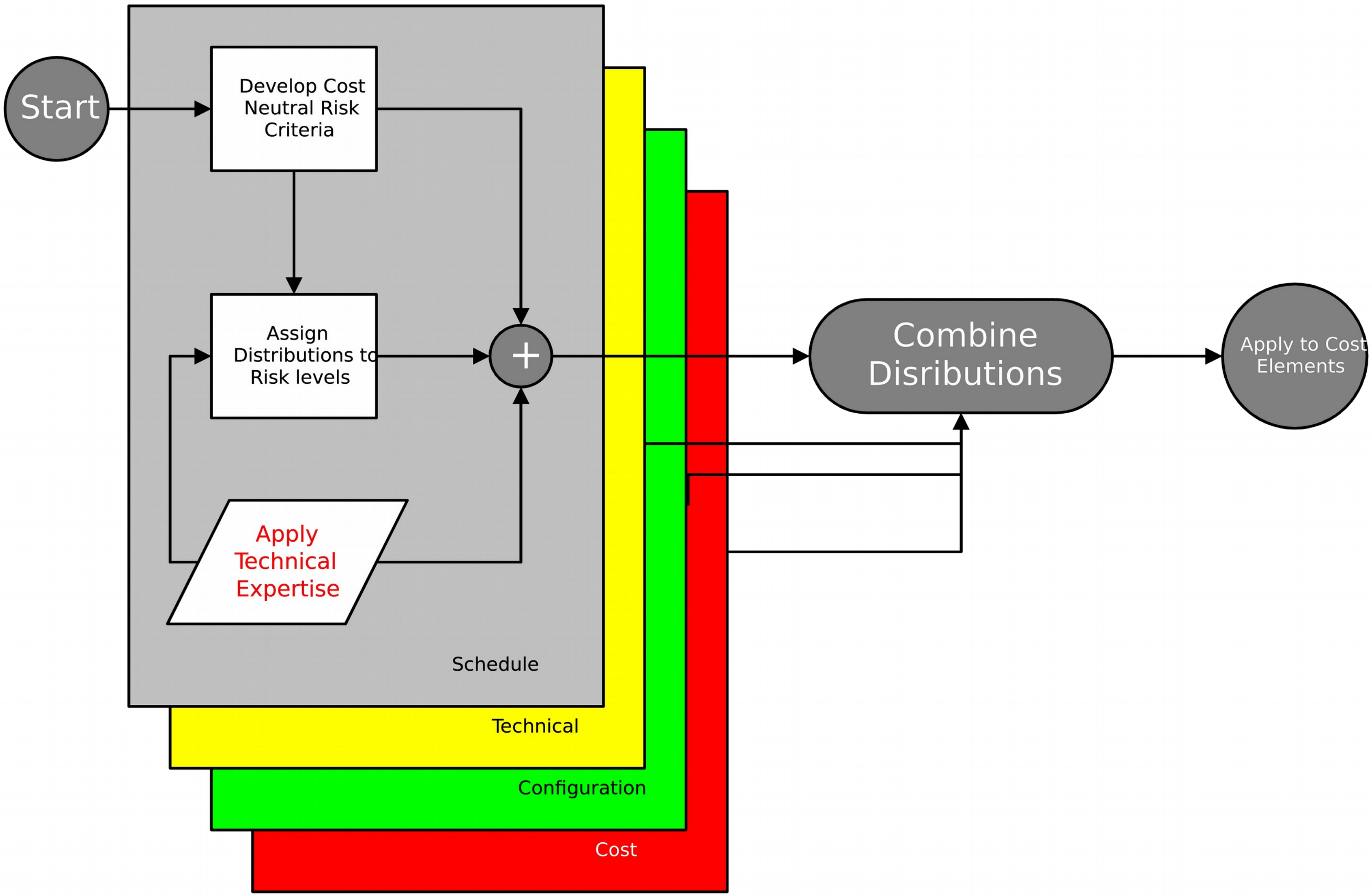
Types of Risk – TSC Risk

- ***TSC risk***
  - ***Represents the unique or unusual technical, schedule, and configuration aspects of the program or the TSC "known unknowns."***
  - ***Evaluated and applied separately from cost risk***
  - ***Further skews the cost risk to simulate TSC unknowns for events occurring outside of the tailored CERs***

Types of Risk – Other Risks

- ***Extremely rare events***
  - ***Political actions or natural disasters***
  - ***Not typically included within the cost estimate***
  - ***Some contingencies for more common events may be included as management reserves***

TSC Risk Assessment - How We Do It



TECOLOTE RESEARCH, INC.

TSC Risk Assessment - How It's Done

- ***The technical and engineering community provides the TSC risk assessment.***
- ***The probability and consequences of the technical, schedule, and configuration concerns are independently evaluated***
  - ***Each item of the WBS is considered at the lowest possible level***
  - ***Compared to historical programs that were executed without significant or unusual technical, schedule, or configuration aberrations.***
- ***The categories are averaged***

TECOLOTE RESEARCH, INC.

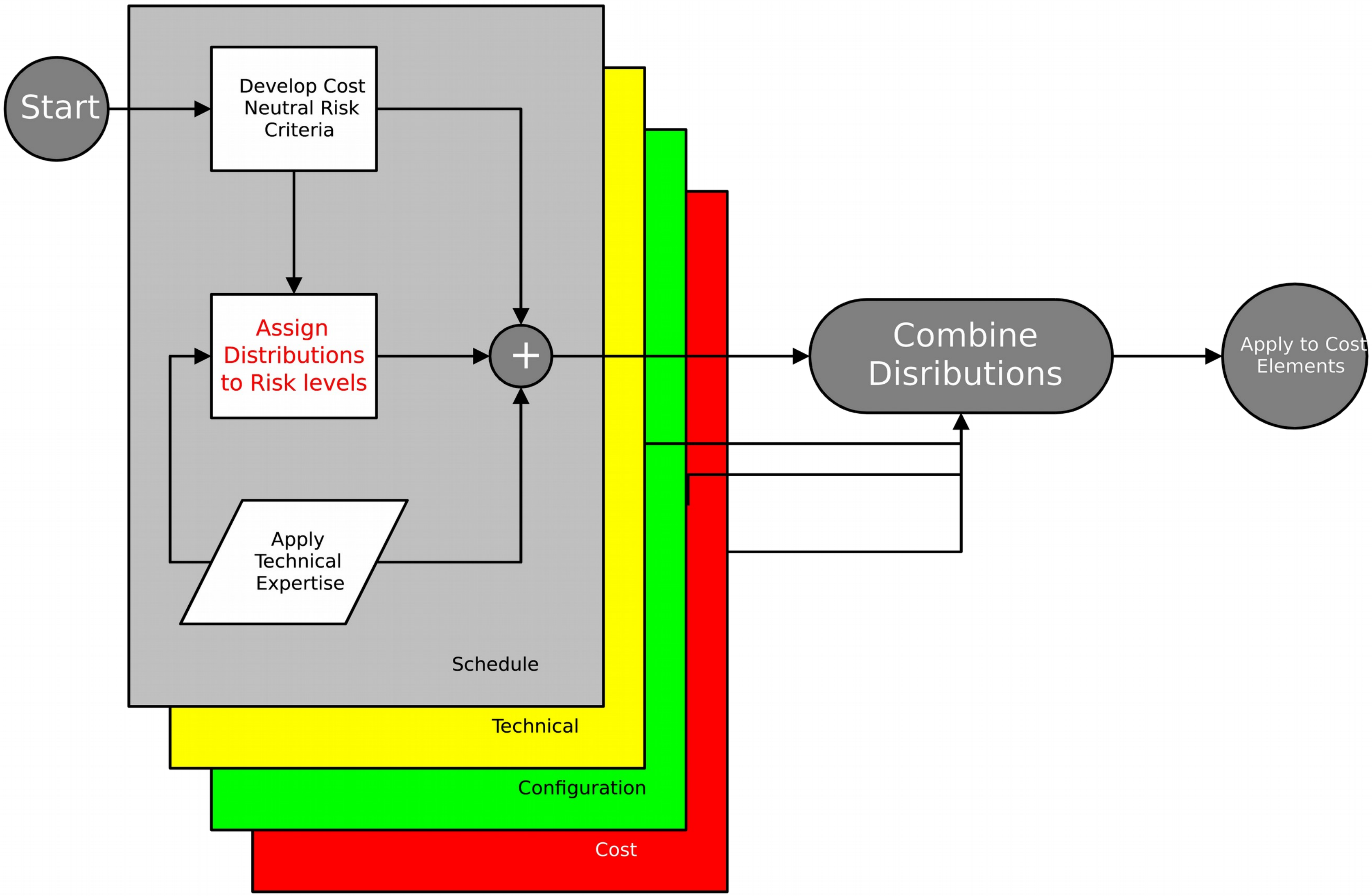
TSC Risk Assessment - Ratings

- ***An overall assessment of the TSC risk for each WBS element is indicated as:***
  - ***Low = “Insignificant”***
  - ***Medium = “Moderate”***
  - ***High = “Substantial”***
  - ***Very High = “Extreme”***
- ***A thorough rationale for the assessment should be included with the reasons for the ratings being annotated***
- ***These results are inherently based on opinions and judgments as opposed to hard***

TSC Risk Assessment - What Can Go Wrong?

- ***Criticisms of the process (biases):***
  - ***Over optimism***
  - ***Inadequate or premature definition of the system***
  - ***Technical maturity assumptions***
  - ***Contract issues***
  - ***Requirement and scope changes***
  - ***Etc.***

TSC Risk Quantification - How We Do It



TECOLOTE RESEARCH, INC.

TSC Risk Quantification Assumptions – Low Risk

- ***TSC risk low boundary for all cases is equal to .9 (90%)***
- ***TSC low risk item has an upper boundary distribution of 1.1 (110%)***
  - ***Based on the commonly accepted [heuristic data] risk range distribution for a stable and established design or program as being plus or minus (+/-) 10%.***

TSC Risk Quantification Assumptions – High Risk

- ***TSC high-risk item is assumed to have an upper boundary of 2.0 (200%)***
  - ***Data shows that the difference between tailored and untailored CERs averages about 200% (Reference 6)***
  - ***Additionally supported by the "common sense" perception that a high degree of risk could result in a doubling of effort, schedule, requirements and resulting costs.***

TSC Risk Quantification Assumptions – Other Assumptions

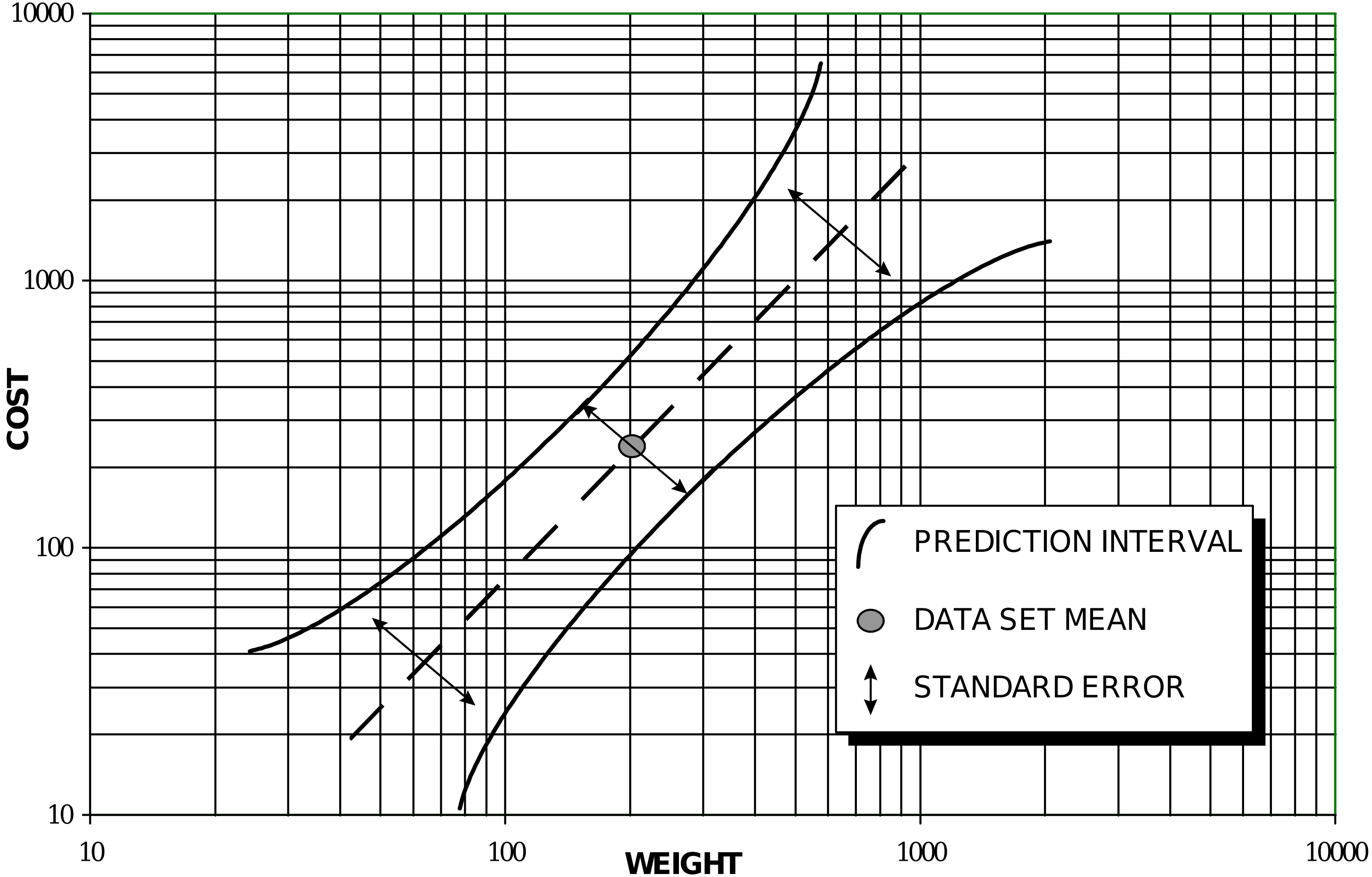
- ***The same (perceptional) degree of TSC risk is incurred going from***
  - ***A low risk item to a medium risk item***
  - ***A medium risk item to a high-risk item***
  - ***A high-risk item to a very high-risk item***
- ***(I.e., each increase in degree of TSC risk is an equal step)***

Establishing TSC Risk Ranges - Procedure

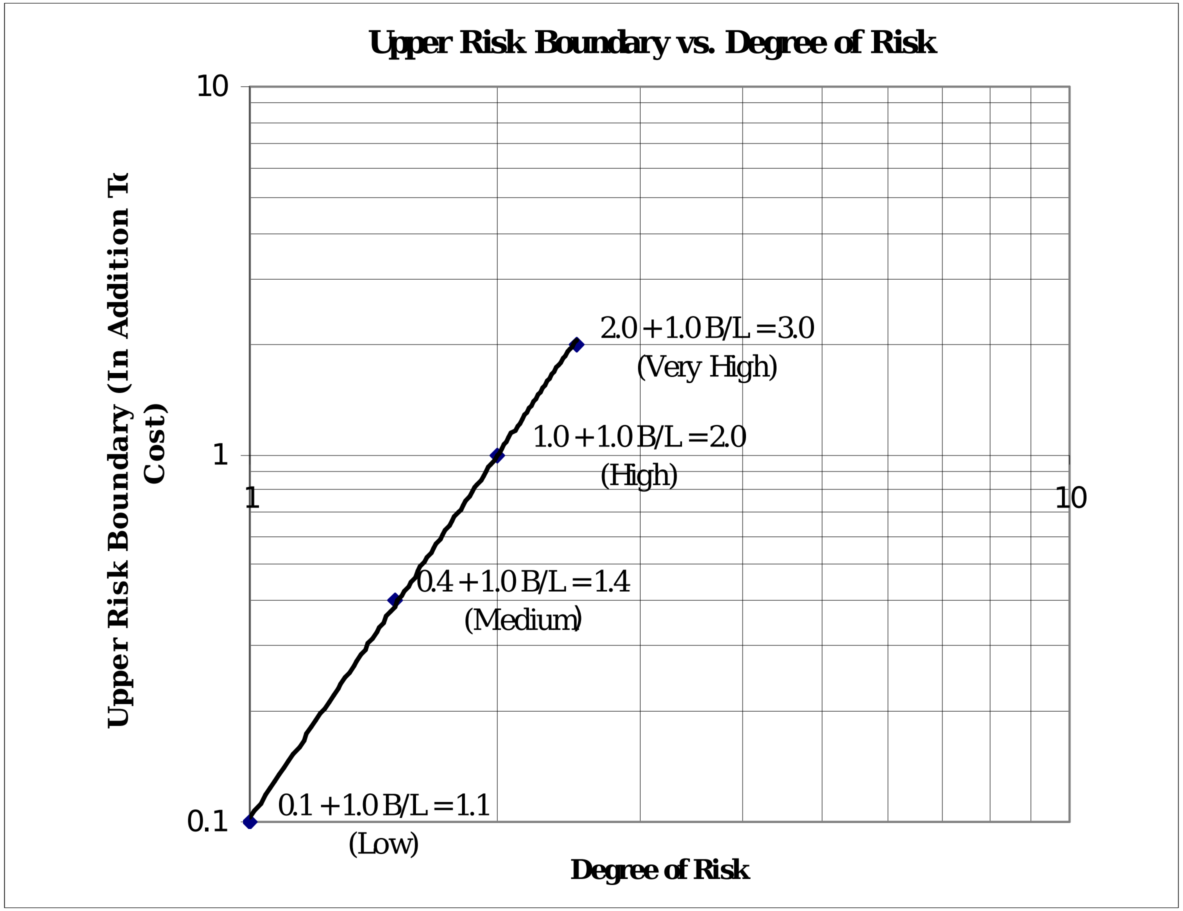
- *Given the low and high data points, the other ranges can then be established*
- *CERs have been tailored to ensure that the independent variables associated with the program(s) being estimated are within the CER range, and to exclude "outliers"*
- *The further from the mean of a data set the greater the "risk"*
  - *As an independent variable deviates further away from the mean CER data point the uncertainty increases in an exponential, log*

Tecolote Research, Inc.

Establishing TSC Risk Ranges - Pictorial of Deviation From Mean



Establishing TSC Risk Ranges - Pictorial of Endpoints



- ***Now, an explanation of this graph….***

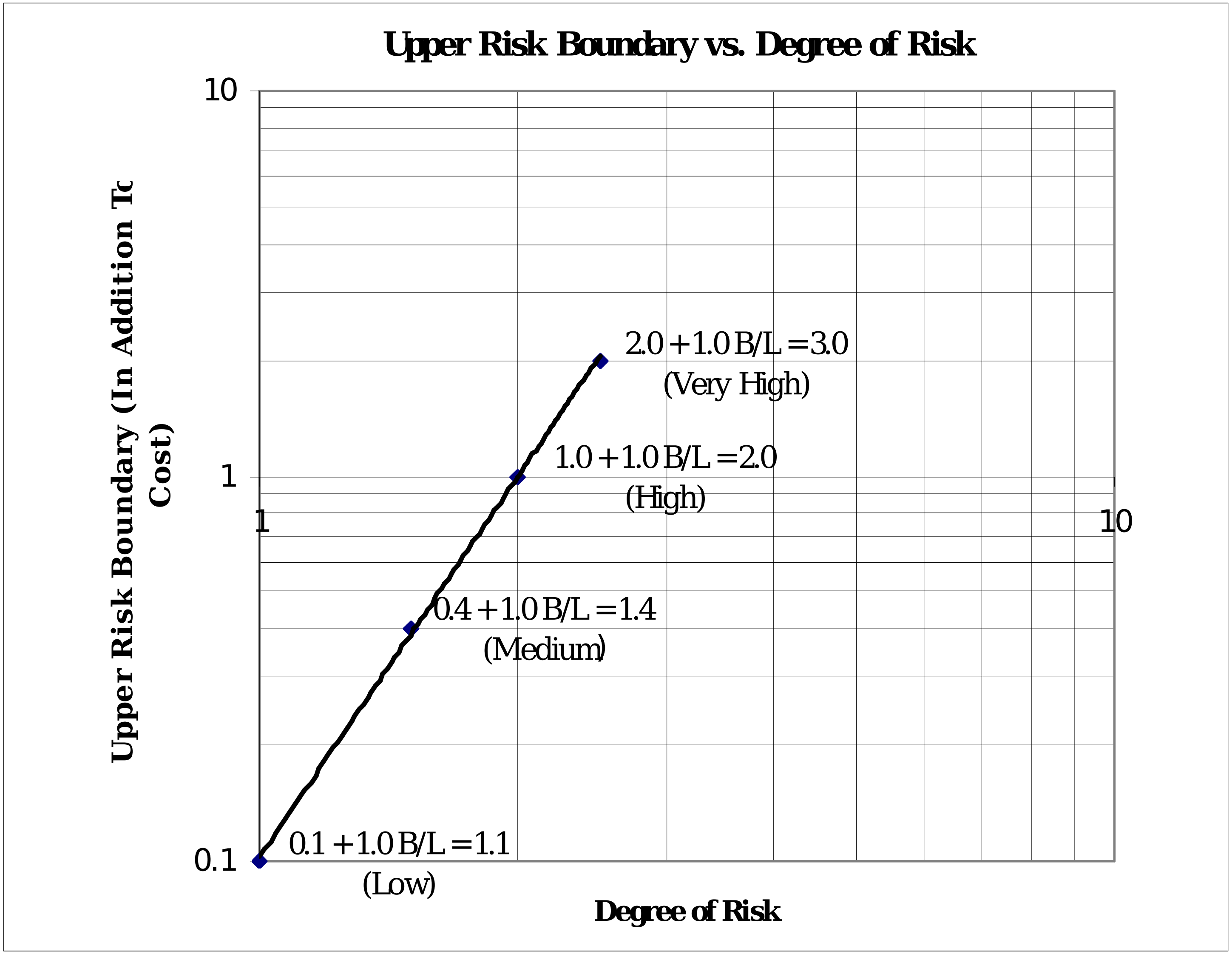
Establishing TSC Risk Ranges – Y Axis

- *Upper risk distributions can be exponentially extrapolated from the known and assumed upper risk distributions*
  - *1.1 for low*
  - *2.0 for high*
- *The remaining upper boundaries of the risk distributions are projected from these data points as a y-axis value*

Establishing TSC Risk Ranges – X axis

- ***Pictorially (on a logarithmic graph) the points are plotted on the x-Axis as degree of risk being:***
- ***Low risk = 1.0***
- ***Medium risk = 1.5***
- ***High risk = 2.0***
- ***Very high risk = 2.5***

Establishing TSC Risk Ranges - Pictorial of Endpoints (Recap)



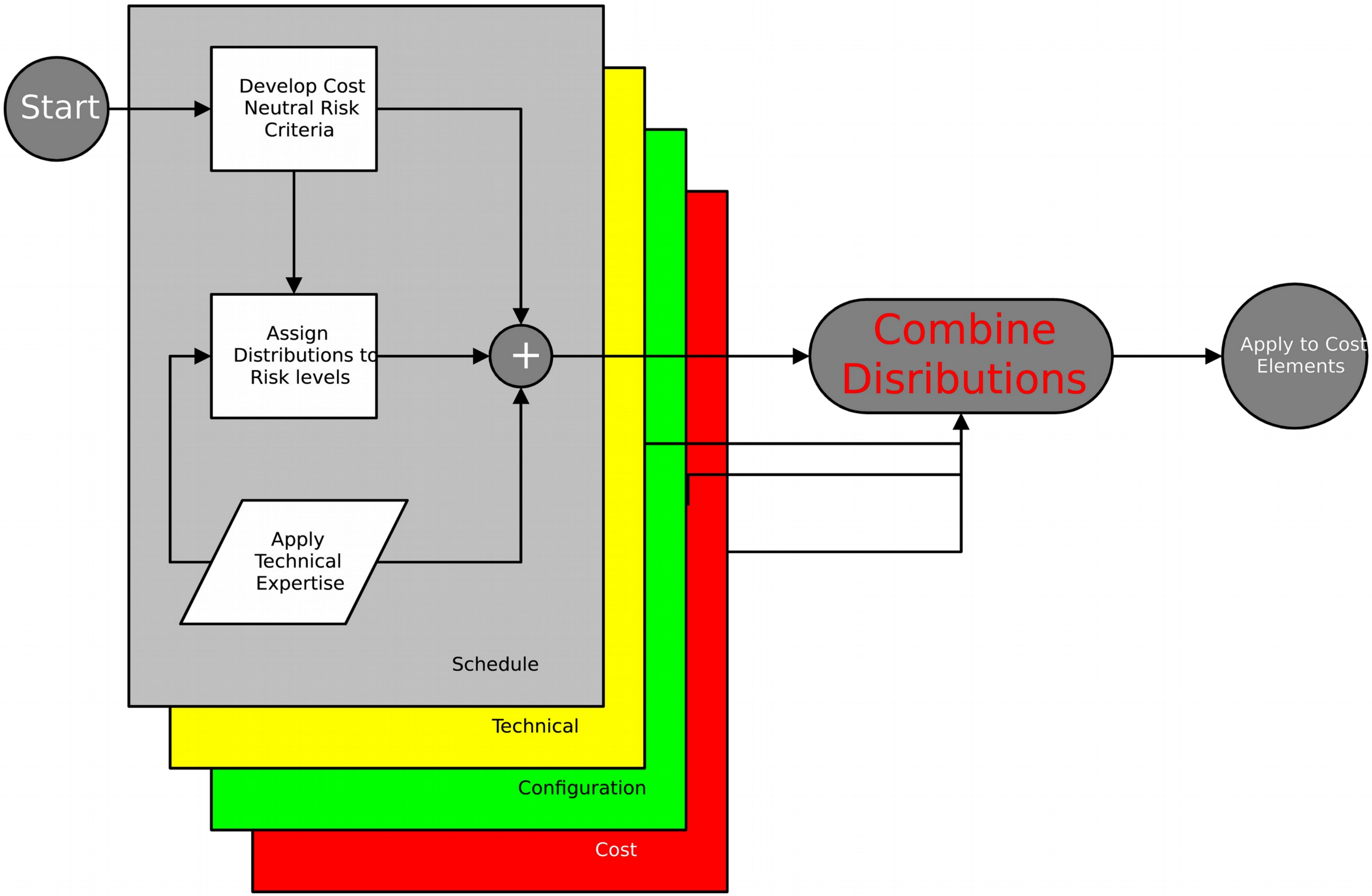
Establishing TSC Risk Ranges – Endpoint Distributions

- ***The y-Axis equals the upper boundary of risk distribution***
  - ***Low risk given as .1 or 10%***
  - ***High risk given as 1.0 or 100%***
- ***TSC risk that is incurred would then calculate as:***
  - ***A medium risk upper bound of + 40%***
  - ***A very high-risk item as having an upper bound of + 200%***
- ***This analysis is valid to two significant***

TSC Risk Range Results - Ranges

- ***The resulting quantification of the risk boundary distributions are summarized as:***
  - ***Low = .9 to 1.1 (90% to 110%)***
  - ***Medium = .9 to 1.4 (90% to 140%)***
  - ***High = .9 to 2.0 (90% to 200%)***
  - ***Very High = .9 to 3.0 (90% to 300%)***
- ***Further refinements of the distribution ranges (such as projecting a low-medium risk) surpass the fidelity of this technique***

TSC Risk Application - How We Do It



TSC Risk Application

- ***The application of these TSC ranges should be modeled in conjunction with the cost risk utilizing Monte Carlo type simulations to determine the overall deviation from point estimate at various confidence levels.***

TECOLOTE RESEARCH, INC.

Collaborating Data

- ***There is substantial and significant acceptance of these ranges***
- ***These results correlate well with other studies***
- ***Findings are collaborated by Selected Acquisition Reports (SAR) data (Reference 1)***
- ***Ranges are accepted and used by the Air Force Cost Analysis Agency (AFCAA)***
- ***Presented to the Office of the Secretary of Defense Cost Analysis Improvement Group (OSD CAIG) without dissent***

Summary

- ***Straightforward technique that assesses and quantifies TSC risks***
- ***Produces reasonable and acceptable results***
- ***Consistent with the limitations of the underlying subjective determination of program uncertainty***
- ***Simple, direct, and common-sense approach***
- ***It works!***

TECOLOTE RESEARCH, INC.

Bridging Engineering and Economics

Since 1973

Backup Charts

References

1) *Tecolote Research, Inc. MFR from John Jack dated 7 September 2003*

2) *Tecolote Research, Inc. CO$TAT and RI$K Training Course, Module 10, “The Prediction Interval,” pages 9-11*

3) *Barry Boehm “Software Engineering Economics,” Figure 21-1, page 311 (© 1981, ISBN# 0-13-822122-7, Prentice Hall PTB)*

4) *BMDO “Cost Risk Methodology” Revision 4 dated April 2001*

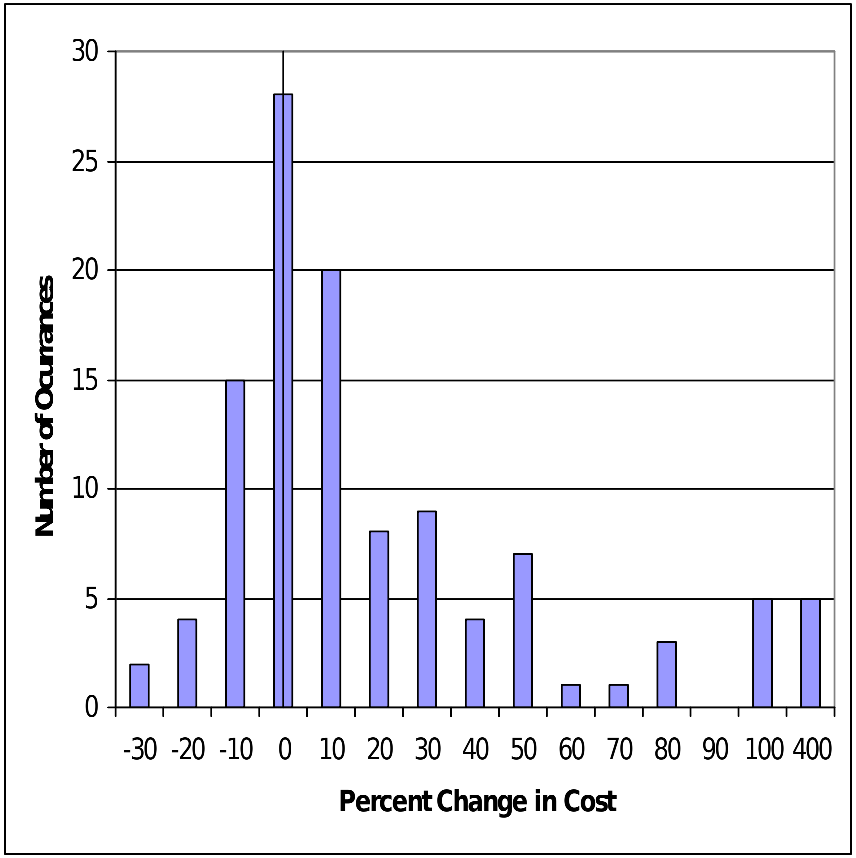
5) *TASC TR-9042-2 “Cost Risk Analysis of the Strategic Defense System,” Revision 1 dated 24 July 1992*

6) *“Risk Factors - Why High Risk = 2x” by Peter Frederic, September 2003*

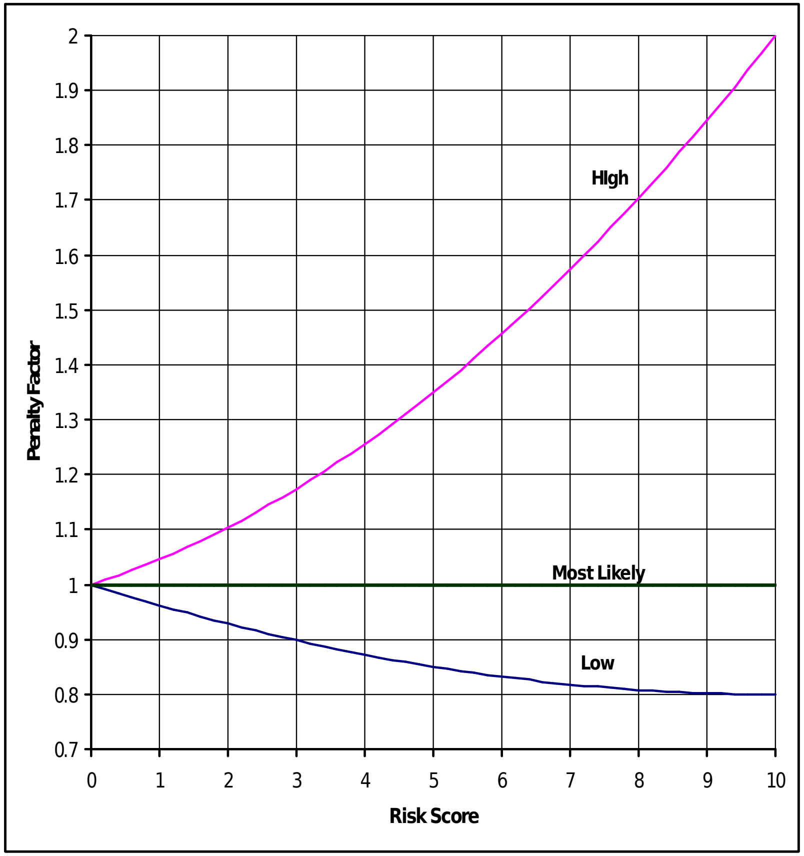
7) *RAND study by Robert Summers in 1979.*

8) *TASC study for the US Air Force in 1983.*

SAR Data - Reference 1



SAR Data Base Frequency Plot



TASC Plot of Polynomial Fits to SAR database

Tecolote Research, Inc.

CER Data - Reference 6

- Sample 1: Solid Rocket Development CER = upper bound roughly 1.75 (a / b)
- Sample 2: Solid Rocket Production CER = upper bound roughly 2.0 at center of database
- Sample 2: Missile Defense System Development CER = upper bound roughly 2.0 at center of database
- Sample 4: USCM 8 Structure/Thermal Nonrecurring CER = upper bound roughly 3.0 at center of database
- Sample 5: USCM 8 Structure/Thermal Recurring CER = upper bound roughly 2.0 at center of database
- Conclusion: “Re-introducing anomalous data points typically drives upper bound of prediction interval up by a factor of 2 (+?), so a risk multiplier of 2 seems appropriate for new items that have a “high” risk of experiencing technical/schedule